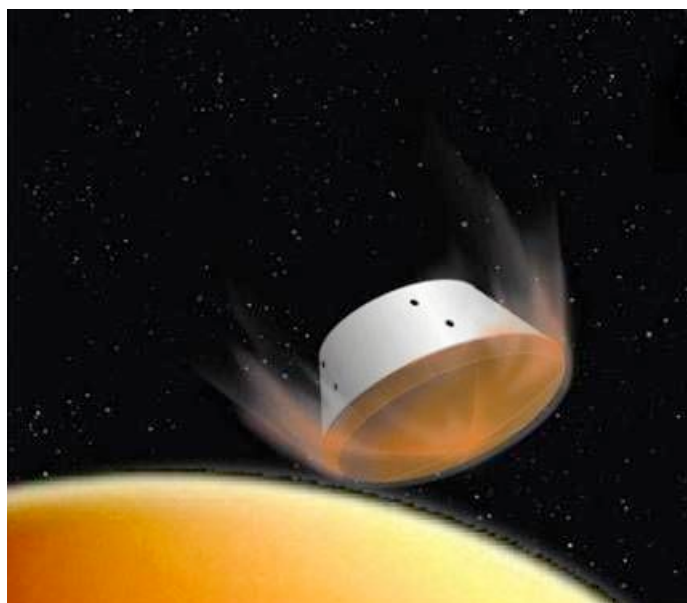


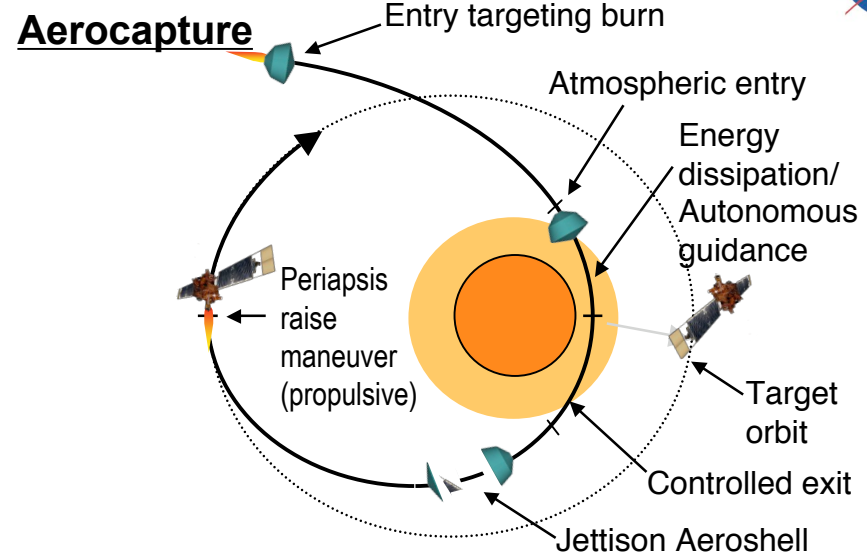
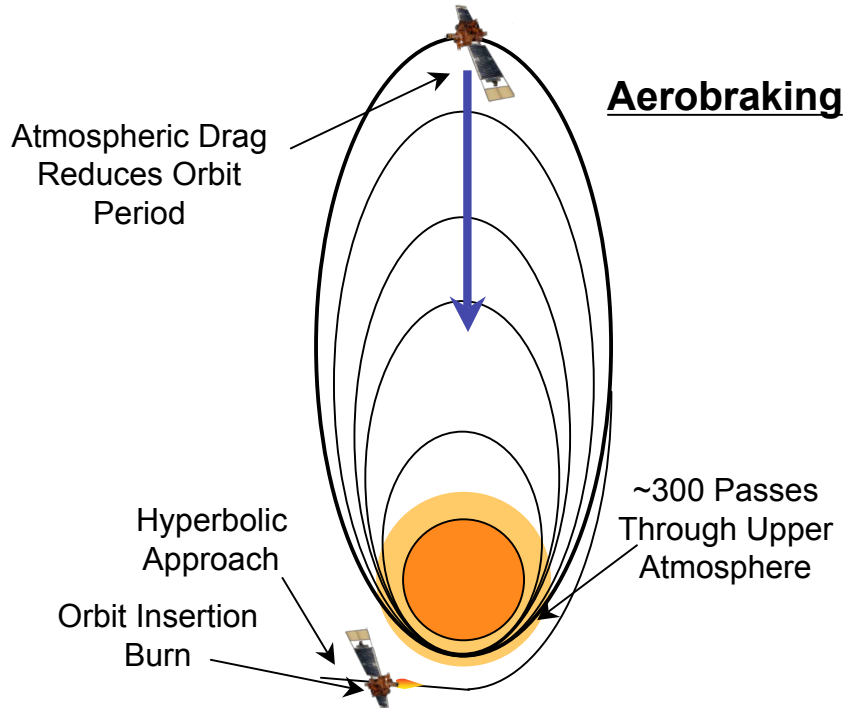
An Aerocapture Snapshot



Michelle M. Munk
Tibor Kremic

March 24, 2008

Aerocapture vs Aerobraking



Aerocapture: A vehicle uses bank angle control to autonomously guide itself to an atmospheric exit target, establishing a final, low orbit about a body in a single atmospheric pass.

Pros	Cons
Little spacecraft design impact	Still need ~1/2 propulsive fuel load
Gradual adjustments; can pause and resume as needed (with fuel)	Hundreds of passes = more chance of failure
Operators make decisions	Months to start science
	Operational distance limited by light time (lag)
	At mercy of highly variable upper atmosphere

Pros	Cons
Uses very little fuel--significant mass savings for larger vehicles	Needs protective aeroshell
Establishes orbit quickly (single pass)	One-shot maneuver; no turning back, much like a lander
Has high heritage in prior hypersonic entry vehicles	Fully dependent on flight software
Flies in mid-atmosphere where dispersions are lower	
Adaptive guidance adjusts to day-of-entry conditions	
Fully autonomous so not distance-limited	

Aerocapture Summary



Aerocapture has Heritage

- Aerocapture can be accomplished at Mars, Titan, Venus and Earth with a high-heritage blunt cone shape like that of existing planetary entry vehicles
- Aerocapture guidance is fully analytic, less than 400 lines of code, derived from Apollo and Shuttle entry guidance (and works at every destination)
- Hypersonic guided entry has been accomplished many times; the only part of aerocapture that has **not** been proven is the atmospheric exit, but skip entry is similar
 - Apollo human-rated a skip entry mode for weather divert but it was never executed
 - Orion will fly skip entry for anytime Lunar return to the US Pacific coast (flight test scheduled for ~2015)--using a numerical guidance of 1000's of lines

Aerocapture is Robust

- An aerocapture system is designed with performance margin to handle worst-case nav, aero, and atmospheric uncertainties. Conservative estimates of variations are used in Monte Carlos.
- Thousands of simulations are run with validated tools to verify performance; *guidance works even with worst-on-worst uncertainties.*
- Guidance allows vehicle to “fly out” density dispersions, which are modeled based on all available data for each planet/moon
- **Aerocapture is much simpler (and easier) than a planetary lander (single flight regime)**

Aerocapture is Not High Risk

- PRA Conducted by SAIC in 2005
- Compared propulsive capture, aerobraking, and aerocapture at Mars
- Results* showed that if the system reliability is normalized so that the reliability of propulsive capture = 1.0, then
 - Aerobraking reliability = 0.9841
 - Aerocapture reliability = 0.9941
- **Aerocapture has HIGHER RELIABILITY than aerobraking, to which we routinely entrust high-dollar missions.**

* Reference: T. Percy, E. Bright, A. Torres, “Assessing the Relative Risk of Aerocapture Using Probabilistic Risk Assessment,” AIAA-2005-4107

Aerocapture Status/Next Steps

- ISPT will complete ground-based development to TRL6 by end of 2009
- Technically, a flight test of Aerocapture is not necessary before use at Titan, Mars, or Venus
- However, a flight validation would mitigate risk perception and immediately prove Aerocapture for multiple mission customers, for a relatively small up-front investment
- Continue to seek a near-term mission infusion or flight validation opportunity.
- Seek to infuse ISPT-developed thermal protection systems to fill gaps in current Agency choices.
- Advocate that heatshield sensors, some developed by ISPT to fly on MSL, be used on every entry vehicle to improve tools and future performance